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INHERITANCE STUDIES OF COLOR AND HORN CHARACTERISTICS

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INHERITANCE STUDIES OF CERTAIN COLOR AND HORN CHARACTERISTICS IN FIRST GENERATION CROSSES OF DAIRY AND BEEF BREEDS.*

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SUMMARY

This constitutes a preliminary paper on the crossbred herd now being brought together by the Maine Agricultural Experiment Station for the purpose of studying some of the outstanding problems of Dairy Husbandry.

No influence on the vigor of the offspring would be expected from the width of the outcrosses as inbreeding studies showed the inbreeding low in amount.

Black body color is dominant to the other colors in the first generation. In the second generation there occurred an orange coated bull and a dark Jersey heifer. This is to be explained on the grounds of a recessive dilution factor in the Guernsey breed. This factor is not normally present in the Jersey breed.

It has been shown that white marking of the body taken as a whole appears as a dominant. Study of the individual white areas, however, indicate that this is due to white in the inguinal region only for this alone appears as such a dominant. The white spots on the face (star, star snip and blaze) neck, shoulders, rump, flanks and legs are, in general, suppressed in the offspring when animals with these markings are mated to solid colored animals.

As has been suggested but as has never been tested before, the pigmented muzzle is dominant to the unpigmented muzzle.

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*Papers from the Biological Laboratory, Maine Agricultural Experiment Station No. 122. This is an abstract of paper No. 120 from the Biological Laboratory of the Maine Agricultural Experiment Station published in the Journal of Agricultural Research. Vol. 15. No. 1.

Agreeing with the previous work of this laboratory it is shown that a pigmented tongue is dominant to a non-pigmented one.

A black switch appears to cause the suppression of the other switch colors in the offspring. Because of this suppression and because all of the matings had at least one animal with a black switch as parent, it was impossible to study the behavior of the other colors. There was one case of segregation of a deep red orange switch from a back cross of a black animal carrying an orange coat and white switch, genetically. This case showed the separation of the factor for this red from that for both white and black.

The character of polledness has been studied. Two horned animals resulting from crosses of polled x horned appeared. On the basis of the other results these could not have resulted from a heterozygous polled condition. One of these cases had the horns tight on the head and the other loose. These cases then form exceptions to the previously accepted hypothesis of simple dominence for the polled character and require a subsidiary hypothesis. The hypothesis suggested is that the male sex organs have some action on the presence or absence of horns. Partial proof of this hypothesis is given by the fact that of the polled animals 10 were females, two males one of which was doubtfully polled. Of those with scurs one female and 7 males had loose scurs; of those with tight scurs all (3) were males; of those with horns, all (2) were males. This would seem like a clear case where the male has some influence. The explanation of this difference appears to be due to a substance secreted by the germ cells. Should this prove true this forms an interesting parallel between cattle and sheep where the sex glands are known to produce such changes.

The inherited characters of the beef type are shown to effect the 4 general regions of the body, head, fore quarters, body and hind quarters differentially. The type of head and heavy, deep fleshed fore quarters are transmitted to the offspring when either parent is of Aberdeen-Angus breed. The body and hind quarters appear intermediate but in most cases resemble the dairy parents.

Data are given on the milk and fat production of some of the crossbreds. The results indicate that milk and fat production are inherited separately. High milk production is dominant to low, high fat per cent is recessive to a low fat per cent in the milk. Put in less technical language the results of this cross indicate that in a cross between an animal from a high milking strain mated to one of a low milking strain, the resulting female offspring will have the milk production of the high strain. In a cross between animals one of which is from a high test line and the other from a low test line the resulting offspring will have a butter fat test of the low test line. The number of these milking first generation females is not great enough to make this statement an absolutely sure conclusion.

INTRODUCTION

The investigation reported in the present paper† deals with the results of 4 years' crosses for certain characters found in the different breeds of domestic cattle. The original plan and three years' direction of the work were carried on by Dr. Raymond Pearl. The present analysis of the material and the further continuance of the studies have, through the exigencies of the war, fallen to the present author. The conclusion expressed as the results of these studies are the author's own and he is alone responsible for them.

This paper is the first of a series which will deal with the inheritance in cattle. The chief objects in undertaking the work have been to learn the mode of inheritance of milk production. Results from such studies are obtained very slowly and are not yet available in sufficient quantity to justify any conclusions.

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†The cattle breeding work has been made possible by the use of the University of Maine herd. In all of this work it has been necessary to to use pure bred animals. By placing their herd at our disposal it has been impossible for the College of Agriculture to build up their pure bred herd. To date more than 50 pure bred matings have been sacrificed for this work. From this time on it will not be necessary to use many of the pure bred females for experimental purposes and will allow the college the opportunity to develop their herd. The Experiment Station desires to express its appreciation of the services rendered in this work by the College and in particular by the Department of Animal Husbandry,—C. D. Woods Director.

There are, however, certain results available relating to the inheritance of external characters, chiefly color markings. It is well known that in other animals certain economic characters are frequently associated in inheritance with similar external features. It is the purpose of this paper to present the available data on the inheritance of these external characters. In later studies the question of the association of these with the character of milk and fat production will be considered.

The breeds used in the crosses are the Jersey, Guernsey, Ayrshire and Holstein-Friesian for the dairy cattle and the Aberdeen-Angus for the beef breed.

THE DETAILED ANALYSIS OF THE INHERITANCE OF THE CHARACTERS IN THE FIRST GENERATION CROSSES.

All of the animals which were used as parents in the formation of this first generation mendelian herd have long been pedigreed.

Inbreeding studies by one of the methods devised in this laboratory of the pedigrees of these parental pure bred animals for four generations, showed the total number of repeated ancestors to be 36 and the total coefficient of inbreeding to be 225.00 percent. The average inbreeding per individual parent of this herd up to the 4th generation, is then, only 9.00 percent. In a previous study from this laboratory of the amount of inbreeding found in pure bred Jersey cattle* it was shown that the average minimum inbreeding coefficient of a sample of Jersey bulls taken at random was 11.01 percent and for the random sample of the Jersey cows was 12.50 percent. For the advanced registry Jersey bulls the minimum inbreeding was 14.88 percent and the advanced registry Jersey cows was 9.23 percent. In each case the inbreeding coefficient is higher than is that of the foundation stock used to form the mendelian herd described in this paper. Again the inbreeding coefficients of 14.50 and 9.23 represent the inbreeding coefficients of the highest producing animals in the breed from which they were selected. Consequently, it is held that since this percentage of inbreeding has not

*Patterson, S. W., Investigation on the degree of inbreeding which exists in American Jersey Cattle. Thesis publications of the University of Maine, Orono.

affected the constitution or vitality of the best animals of a high producing breed, the width of the crosses will not influence the vigor of the hybrids described in the succeeding pages.

The parents used in the crosses possess the following contrasting characters seen in Table I.

TABLE I.

Contrasting Characters of the Parental Breeds of the Crossbred Herd.

Character	Jersey	Guernsey	Ayrshire	Holstein-Friesian	Aberdeen-Angus
Body Color	Fawn or Dun	Light Fawn or Dun	Red	Black	Black
White markings	Often absent	Present	Present	Present	Often absent
Switch color	Black or white	Light fawn or white	Red or white	Black or white	Black
Muzzle pigment	Black	White	Black	Black or white	Black
Tongue pigment	Black	White	Black	Black or white	Black
Horns	Horns	Horns	Horns	Horns	Polled
Conformation	Dairy	Dairy	Dairy	Dairy	Beef
Milk quantity	Medium	Medium	Medium	Large	Low
Milk quality	High	High	Medium	Low	High

The Inheritance of Body Color.

The data for the study of the body color are given in the table below.

TABLE II.

Inheritance of Ground Color in the Cattle Coat.[2]

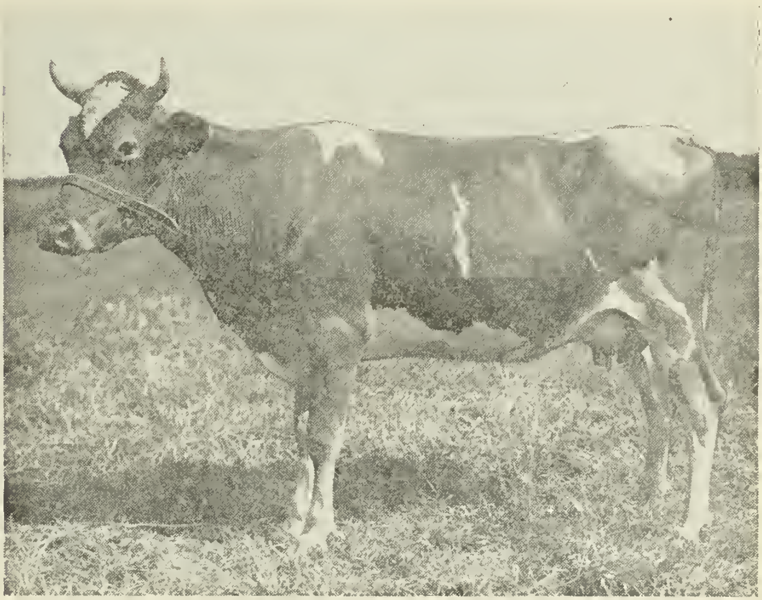
Mating.			Character of resulting offspring.
Sire		Dam	
Black	×	Black	10 Black
Black	×	Fawn	23 Black
Black	×	Red	4 Black 8 Black
Black	×	$F_1\ \frac{\text{Black}}{\text{Fawn}}$	2 Black
$F_1\ \frac{\text{Black}}{\text{Fawn}}$	×	Fawn	1 Black, 1 Dark Dun 1 Deep Orange
$F_1\ \frac{\text{Black}}{\text{Fawn}}$	×	$F_1\ \frac{\text{Black}}{\text{Fawn}}$	3 Black

The data in this table reaffirm the conclusion of Spillman,[3] Wilson,[4] and others that black is dominant to the red and yellow coats (so called fawns). The number in the second generation from the cross are not large enough, as yet, to establish any facts regarding the proportions between the animals of the different kinds of coats resulting from breeding these first generation animals together. The apearance of the dark fawn and deep orange offspring from Black F_1, parents indicate that such reappearance of the parental types of coat color does occur.

Crossbred No. 38.

This second generation bull comes from the cross of a black first cross bull Aberdeen-Angus-Guernsey x Guernsey. He is solid orange in color, carries horns, and has the light eye ring and muzzle color of the Guernsey breed. The conformation resembles the Guernsey especially in the region of the loin, chine and tail set.

Crossbred Number 38, the deep orange coated bull shown in the photograph, is of special interest as the coat of the Guernsey parent has reappeared in a much deeper shade. This deepening of the shade seems to be confirmatory evidence for the hypothesis advanced by Wright[5] that Guernsey cattle differ from the other dun colored breeds by a hereditary unit which dilutes the dun color. This hereditary unit must be recessive as the cross was made as a backcross of the first hybrid male $\frac{\text{Aberdeen-Angus}}{\text{Guernsey}}$ onto a Guernsey cow. Furthermore, this factor cannot follow sex (be sex-linked) for the way the cross was made eliminates this possibility, as the Guernsey mother would have to transmit all of her recessive factors to her male offspring. Consequently, this factor cannot be considered in the class with that for the brown of the Ayrshire coat which Wentworth says is dependent for its shade on a recessive sex-linked dilution factor. The almost identical appearance of the dark dun second generation heifer and her Jersey parent indicate that in the Jerseys any such dilution factor as that in the Guernsey is not normally present.



CREUSA'S LADY. 53234.

This Guernsey cow shows the typical white marking of the breed. The presence of the star is quite characteristic. It is this marking which we have studied in our crosses for the inheritance of white on the head.

DIFFERENCE IN INHERITANCE OF THE WHITE SPOTS IN CATTLE COATS.

A preliminary study of the white markings found in the coats of dairy cattle satisfied the author that the areas, (star, star strip and blaze; neck; shoulders; rump; flanks; legs and belly) designated by Allen as the principal divisions of this white were correct. Creusa's Lady shows the typical white spotting of an animal bearing a number of these areas.

The exact descriptions, including photographs of both sides of all the animals made it possible to study the inheritance of these areas considered separately, as well as present or absent for the animal's whole coat. Table III treats the inheritance of two of the white areas for white markings into which the coats have been found to be divisible.

TABLE III.

Inheritance of White Markings.

Mating.			Character of resulting offspring.
Sire		Dam	
Piebald	×	Solid Color	5 Solid Color, 10 Piebald
Solid Color	×	Piebald	2 Solid Color, 3 Piebald
Piebald	×	Piebald	6 Solid Color, 22 Piebald
Solid Color	×	Solid Color	1 Solid Color
F_1 Piebald / Solid Color	×	Solid Color	2 Solid Color
F_1 Piebald / Solid Color	×	Piebald / Solid Color	3 Piebald

The breeding tests made it clear that the bulls were all heterozygous for the piebald factor on the single factor hypothesis. Such being the case piebald x solid color gave more piebalds than would be expected of a good back cross ratio (5 to 10) and the mating of piebald by piebald (6 solid colored to 22 piebald) slightly more than a good F_2 ratio. These ratios always favor the piebald and taken in consideration with other investigations make it doubtful if any such simple hypothesis of a single mendelian factor explains the facts. Furthermore, the results set forth in the above table could equally well be explained by the presence of a dominant factor for a white spot in the coat together with several recessive factors. This is in truth the explanation indicated from the results of Table IV and V, inserted to show the typical behavior in inheritance for white spots of two of the above mentioned areas.

TABLE IV.

Inheritance of the White Markings on the Face (star).

Mating.			Character of resulting offspring.
Sire		Dam	
Star	×	Star	1 Solid Color, 3 Star
Star	×	Solid Color	10 Solid Color, 3 Star
Solid Color	×	Star	15 Solid Color, 1 Star
Solid Color	×	Solid Color	13 Solid Color
F_1 Star	×	Star / Solid Color	1 Star
F_1 Star / Solid Color	×	Solid Color	2 Solid Color
F_1 Star / Solid Color	×	Star	1 Solid Color
F_1 Star / Solid Color	×	Star / Solid Color	2 Star, 1 Solid Color

TABLE V.

Inheritance of the White Markings of the Inguinal Region.

Mating.			Character of resulting offspring.
Sire		Dam	
Inguinal Spot	×	Inguinal Spot	19 Inguinal Spot, 5 Solid Color
Inguinal Spot	×	Solid Color	10 Inguinal Spot, 6 Solid Color
Solid Color	×	Inguinal Spot	4 Inguinal Spot
Solid Color	×	Solid Color	1 Inguinal Spot, 2 Solid Color
F_1 Inguinal Spot / Solid Color	×	Solid Color	2 Solid Color
F_1 Inguinal Spot / Solid Color	×	Inguinal Spot	2 Inguinal Spot, 1 Solid Color

The difference in the inheritance of these two white areas is evident even with a casual glance. White on the forehead is in general recessive to solid color for solid color mated to star gives 15 solid color to 1 star. The case is not strictly mendelian for in the mating of star by star one solid colored animal resulted. This animal was out of a Guernsey cow with a very small star, in fact only a few hairs, and by a bull with a large star. The matings of Table V point strongly to the conclusion that white in the region of the udder is dominant. This dominance is not strict for one solid colored bull mated to a solid colored cow produced an animal with an inguinal spot.

Table IV is typical of the behavior in inheritance of the other white areas found on the neck, shoulders, rump, flanks and legs. Individually considered, they all are suppressed when the cross includes one pure solid colored animal (that is, the above areas are recessive to solid color) for the given region. This recessive quality of the hereditary units for this white is not strict in any of the regions as one or two exceptions occur in each case. It is conceivable that there would be an association between the inheritance of the different individual spots. No such correlation has, as yet, been made out. In fact, the data are too limited to make any such correlations which might be established, significant.

The difficulties experienced in the explanation of the inheritance of the Shorthorn coat color, red, white and red and white are familiar to all breeders of cattle. In the study of the Roan coat of this breed about the only thing which the results of Wilson, Laughlin, Wentworth, Pearson and Walthers have in common are exceptions which each found to the interpretations offered by the other writers. A beginning at a solution of these exceptions has been made by the excellent review of the writings of Storer, Wilsdorf and others on white body color by Lloyd-Jones and Evvard. In this review they show that two types of identical white body with colored ears exist. In the Chillingham cattle this white is dominant. In the Highland cattle it is recessive.

The demonstration of such a difference in inheritance of white as that in the above mentioned breed does not quite hit the case of the Roan Shorthorn for, while the presence of these two genetically different whites would complicate the results, it is likely that their presence would be noted because the pattern of each is so striking. It does remain to be shown rather that the piebald cattle, like the Shorthorn, have a difference in behavior of the separate spots which compose this piebald. A beginning of this kind of analysis has been made by Kiesel according to a review by Lang. In these experiments a solid colored Limburger race was crossed to a piebald race. The first generation hybrids were intermediate piebald. The back cross gave 22 solid colored and 29 piebald. The cross to the piebald first generation hybrids gave out of 90 offspring, 84 piebald. Unfortunately, no record of the exact spotting has been given, consequently, we are left in the dark concerning any difference in behavior throughout the coat. It would seem, however, that his results, would fall in line with the results obtained here, where each individual area is treated separately.

Analyzed by this method, there has been shown to be a marked difference in the inheritance of the individual white spots throughout the animal's coat. This is, perhaps, as far as we should go and is the only conclusion it is intended to emphasize, but realizing that there are exceptions not yet accounted for we may say white spotting in the inguinal region is, broadly speaking, dominant. The spots of the rest of the piebald pattern are, individually considered, recessive. These enumerated individually, according to the region in which they occur, are white on the face (star, star snip or blaze); on the throat; as a band across the shoulders; as a white area on the rump at the base of the tail set; on the flanks as irregular spots; white on the tail above the switch and the white stockings on the fore feet.

The bearing of this difference in inherited behavior on the general problem is at once evident. If a red coated Shorthorn should carry one of these recessive white spots we should expect a small proportion of cattle produced from the random mating of such an animal in the Shorthorn population would be white spotted. This is what has actually been obtained in point of fact. The reverse is also true that if these dominant whites are mated together, we should expect that a heterozygous mating would now and then take place giving a red. The evidence brought forward offers a straightforward, clear explanation of the anomolous behavior of the Shorthorn coat.

ON THE INHERITANCE OF SWITCH COLOR.

Since all of our parental generations had at least one member of the mated pair with a black switch, it was only possible to determine that this black suppressed (was dominant to) the other colors, red, cream and white in the first hybrid generation. In the second hybrid generation a bull with a deep orange switch was produced from a black first hybrid gereration bull, $\frac{\text{black}}{\text{white}}$ Guernsey, bred back to white (Guernsey). To produce this switch color a double separation of the hereditary units must have taken place in the germ cells of the black first generation parent bull. The black of the Aberdeen Angus and the white of the Guernsey were segregated out from the fawn of the Guernsey coat. This fawn must have been further separated from the dilution factor for the fawn normally present in the Guernsey coat. The data for these crosses are shown in the Table VI below.

TABLE VI.

Inheritance of Switch Color.

Mating.			Character of resulting offspring.
Sire		Dam	
White	×	Black	3 Black, 5 White, 2 Black and White
White	×	Brown	1 Black and White
Black	×	White	12 Black, 2 Black and White
White	×	White	4 White, 1 White, few black hairs
Black	×	Black	9 Black
Black	×	Black, red and gray	3 Black
F_1 $\frac{\text{Black}}{\text{White}}$	×	Black	2 Black
F_1 $\frac{\text{Black}}{\text{White}}$	×	F_1 $\frac{\text{Black}}{\text{White}}$	1 White
F_1 $\frac{\text{Black}}{\text{White}}$	×	F_1 $\frac{\text{Black and White}}{\text{White}}$	1 White
F_1 $\frac{\text{Black}}{\text{White}}$	×	White	1 Black, 1 Orange

The dominance of black is easily seen from the table. Black by black gave all black. White by black gave 3 black, 5 white and 2 black and white, showing that many animals with a black switch carry the recessive white factor suppressed. In the second generation a number of cases of segregation of the white from the black and of solid colored red from the white and black appeared lending further evidence toward the single unit nature of the inherited factors behind these colors.

ON THE INHERITANCE OF MUZZLE PIGMENT.

The evidence gathered together in Table VII shows that the suggestion made by Spillman without the presentation of evidence that the pigmented muzzle was dominant to the unpigmented condition was a correct interpretation of the facts of the case.

TABLE VII.

Inheritance of Muzzle Pigment.

Mating.			Character of resulting offspring.
Sire		Dam	
White	×	Pigmented	14 Pigmented
Pigmented	×	Pigmented	23 Pigmented
Pigmented	×	White	3 Pigmented
White	×	F_1 Pigmented / White	1 White with small black spots
F_1 Pigmented / White	×	Pigmented	3 Pigmented
F_1 Pigmented / White	×	Pigmented / White	3 Pigmented

This table shows that in the first generation of crosses of pigmented x pigmented there were 23 animals produced with pigmented muzzles. One case where a modified form of separation of the pigmented from the white condition is seen in one of the second generation animals where the muzzle was white with small black spots scattered over it. These results easily prove the pigmented condition dominant to the unpigmented.

ON THE INHERITANCE OF TONGUE PIGMENT.

In a previous paper from this laboratory[6] the pigmented condition of the tongue in Jersey cattle was shown to be dominant to the unpigmented condition. The table given below extends this conclusion to the other breeds which have been used in the crosses for our crossbred herd.

TABLE VIII.

Inheritance of Tongue Pigment.

Mating.			Character of resulting offspring.
Sire		Dam	
White	×	White	3 White
White	×	Pigmented	7 Pigmented, 1 Pigmented and White
Pigmented	×	White	11 Pigmented, 2 White, 3 Pigmented and White
Pigmented	×	Pigmented	10 Pigmented
Pigmented / White	×	Pigmented	2 Pigmented
Pigmented / White	×	Pigmented / White	2 White
Pigmented / White	×	White	1 White

In these crosses pigmented x pigmented gave all pigmented, white x white gave all white, and crosses of pigmented x white produced largely pigmented offspring. The second generation offspring from pigmented tongued hybrids both came white tongues showing the separation of the factors for the pigmented and unpigment condition in the first generation parents. These facts strengthen the hypothesis that the pigmented condition of the tongue is inherited through a dominant factor.

THE INHERITANCE OF THE HORNED CONDITION.

The inheritance of the polled condition as a simple mendelian dominant was first suggested by Bateson and Saunders[7] through their studies on show cattle. Spillman in further studies during the year 1905 confirms this view and makes the interesting suggestion without support of numerical evidence, that the horned condition is dependent to some extent on sex. This suggestion, although denied by later investigators, has proved helpful in explaining certain exceptions to the strict mendelian explanation which occurred in our data. The table shown below records the data of these crosses according to sex.

TABLE IX.

Relation of Sex to the Horned Condition in Cattle.

Mating.		Character of resulting offspring.							
Sire	Dam	Polled		Scurred					
				Solidly attached		Loosely attached		Horned	
		Male	Female	Male	Female	Male	Female	Male	Female
Horned	Polled	1	3			1	1	1	
Polled	Horned	1	(?) 7	3		6		1	

CROSSBRED NO. 21.

This bull is the progeny of Kayan (Aberdeen-Angus clean polled bull) mated with Dot Alaska (Ayrshire). Note the heavy solidly attached horns grown while only a year and four months old. The Aberdeen-Angus blood is plainly seen in the heavy beefy conformation of this bull. The other horned animal had horns even longer than these at this age.

The polled character in the offspring of these crosses occurs most frequently in the females. In 7 offspring from matings of horned males with polled females, 3 polled females were produced to 1 polled male. One male and 1 female had scurs and 1 male had heavy horns. In the reciprocal cross of polled male bred with horned female, 1 male was doubtfully recorded as loose scurs under the skin. He died before this could be checked. Of the others 7 females were polled, 3 males had solidly attached scurs, 6 had loose scurs and 1 was horned. Crossbred No. 21 shows this horned condition.

These data make it probable that sex has some influence on the horned condition. The parallel with the case of sheep is of special interest for castration experiments have established the presence of a secretion by the testis which materially aids the production of horns with this species. On the basis of this the testis in the bull would be expected to secrete a hormone which would allow him to grow horns with one dose of the horned genes where two doses of the horned gene would be required by the female. The parallel is still further emphasized by the variability, both intra and interracially and in the length of time necessary for its action in producing horns, as this work has shown for cattle and as the work of Arkell[8] has shown for sheep. This may be the explanation of the results obtained by Lloyd-Jones and Evvard[9] where out of 78 offspring of a Shorthorn bull to Galloway cows they obtained only 6 scurred and two horned animals. Here it is conceivable that in this cross the secretion may be lacking or very small in amount as in some of the Merinos that Arkell bred. That is, the concentration or amount of the secretion may be lower in Galloway crosses than it is in Aberdeen-Angus crosses. In all events the secretion in cattle seems intermediate in its action between the reindeer and the sheep since castration of horned breeds does not retard the horn growth although it does tend to make the horn longer and more slender.

THE INHERITANCE OF BEEF AND DAIRY CONFORMATION.

The component elements which go to make up conformation or type are obviously complex. In the crosses of the two types, dairy and beef, the offspring break up more or less strictly into the two types for four quite definite regions. These may be designated the head, fore quarters, barrel and hind quarters. These crossbreds have been divided into 4 catagories, beef, beef and milk, milk and beef and milk as they approach the ideal beef or dairy type in any of the above named regions. Hearthbloom, one of the parental animals of the distinctly beef type is shown in the photograph below.

Hearthbloom 147141.

This animal illustrates the rounded blocky conformation typical of the Aberdeen-Angus breed. She is of a very good beef type. Her offspring are some of the best animals in this study of the inheritance of the beef and dairy conformation. In connection with the section devoted to the inheritance of the horned condition notice that this animal is cleanly polled.

To save space I will tabulate only two of the regions as these are typical of the rest.

TABLE X.

Inheritance of Conformation.

Fore Quarters.

Mating.			Character of resulting offspring.
Sire		Dam	
Beef	×	Milk	6 Beef, 14 Beef and Milk
Milk	×	Beef	8 Beef and Milk, 1 Milk and Beef
Milk	×	Milk	14 Milk
Milk	×	Milk and Beef	3 Milk and Beef, 1 Milk
F_1 Beef/Milk	×	Milk	1 Milk and Beef

Hind Quarters.

Mating.			Character of resulting offspring.
Sire		Dam	
Beef	×	Milk	1 Beef, 6 Beef and Milk, 11 Milk and Beef
Beef	×	Milk and Beef	1 Beef and Milk, 1 Milk and Beef
Milk	×	Beef	1 Beef and Milk, 8 Milk and Beef
Milk	×	Milk	14 Milk
Milk	×	Milk and Beef	3 Milk, 1 Milk and Beef
F_1 Beef/Milk	×	Milk	1 Milk

Most of the F_1 offspring are intermediate in type. The proportion of animals with the beef conformation is quite different for the two regions. In general it would seem that in the head and shoulder the conformation of these F_1 crosses tended toward the beef type, while in the region of the barrel and hind quarters the conformation was more like the dairy type.

ON THE INHERITANCE OF MILK AND BUTTER FAT PRODUCTION.

Since the results of any study of milk production is of so much economic and scientific interest the data on the results for the comparison of the milk production of 4 F_1 crossbred heifers are presented. The production of these animals is corrected to its expected maximum by the method previously devised in this laboratory.

TABLE XI.

Inheritance of Milk Production.

Daughter's Production.

No.	Breed of Sire	Age	Days in Milk	Production	Corrected Maximum for 100 Days	Difference Daughter Dam Production
1	Jersey	2-0-5	110	2016	2666	
2	Holstein-Friesian	2-8-26	105	3035	3722	
11	Jersey	2-3-22	110	2234	2791	
12	Holstein-Friesian	2-4-7	93	2314	3405	

Dam's Production.

	Breed of Dam	Age	Days in Milk	Production	Corrected Maximum for 100 Days	Difference Daughter Dam Production
	Holstein-Friesian	10-8-14	104	3579	3600	—934
	Guernsey	3-9-2	96	2243	2718	+1004
	Holstein-Friesian	5-4-20	123	3168	2686	+105
	Guernsey	4-4-5	109	1830	1881	+1524

TABLE XII.

Inheritance of Fat Content.

Daughter's Production.

No.	Breed of Sire	Age	Days in Milk	Production Fat Per cent	Corrected Maximum Fat Per cent	Difference Daughter Dam Production
1	Jersey	2-0-5	110	4.4	4.4	
2	Holstein-Friesian	2-8-26	105	3.2	3.2	
11	Jersey	2-3-22	110	3.2	3.2	
12	Holstein-Friesian	2-4-7	93	3.5	3.5	

Dam's Production.

	Breed of Dam	Age	Days in Milk	Production Fat Per cent	Corrected Maximum Fat Per cent	Difference Daughter Dam Production
	Holstein-Friesian	10-8-14	104	2.5	2.7	+1.7
	Guernsey	3-9-2	96	3.4	3.5	—0.3
	Holstein-Friesian	5-4-20	123	3.6	3.8	—0.6
	Guernsey	4-4-5	109	5.4	5.6	—2.1

All 4 heifers are from one parent of a high producing strain at the expense of quality and the other parent a low producing strain but high in quality. The corrected maximum production is the amount expected of the cows when they reach their maximum production at mature form. The production of Number 1 seems abnormal due probably to her growth being poor as a calf. Her second lactation approaches more nearly the normal of her capacity with proper nutrition. In this lactation she produced an expected maximum for the 100 day period of 3246 pounds of milk and 3.6 for the fat percent.

The difference between the production of these heifers and that of their dams show, in general, that they produce the quantity of milk expected of the high producing strains and the quality of the low quality breed. Or put in another way, these facts support the hypothesis that in a cross of high producing lines to low producing lines the offspring tend to have the high production of the high lines. Further, the offspring of a parent producing a milk of low fat content tends to have the low content of the low parent even though the other parent may be from a high fat content line.

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